Dennis, Clyde Avery B.S.

Aquatic Gastropods of the Bass Island Region of Lake Erie

QL430.4
D43

UNIVERSITY OF RHODE ISLAND LIBRARY

Gaylord
PAMPHLET BINDER
Syracuse, N. Y.
Stockton, Calif.

THE OHIO STATE UNIVERSITY
THE FRANZ THEODORE STONE LABORATORY
CONTRIBUTION No. 8

AQUATIC GASTROPODS OF THE BASS ISLAND REGION OF LAKE ERIE

By
CLYDE AVERY DENNIS, B.S.

RECEIVED
MAY 10 1961
NARRAGANSETT MARINE
LABORATORY LIBRARY

OHIO STATE UNIVERSITY
1928

THE FRANZ THEODORE STONE LABORATORY

PUT-IN-BAY, OHIO

THOMAS H. LANGLOIS, Director

Operated by The Ohio State University throughout each calendar year for scientific research and for application of the research method of education for action.

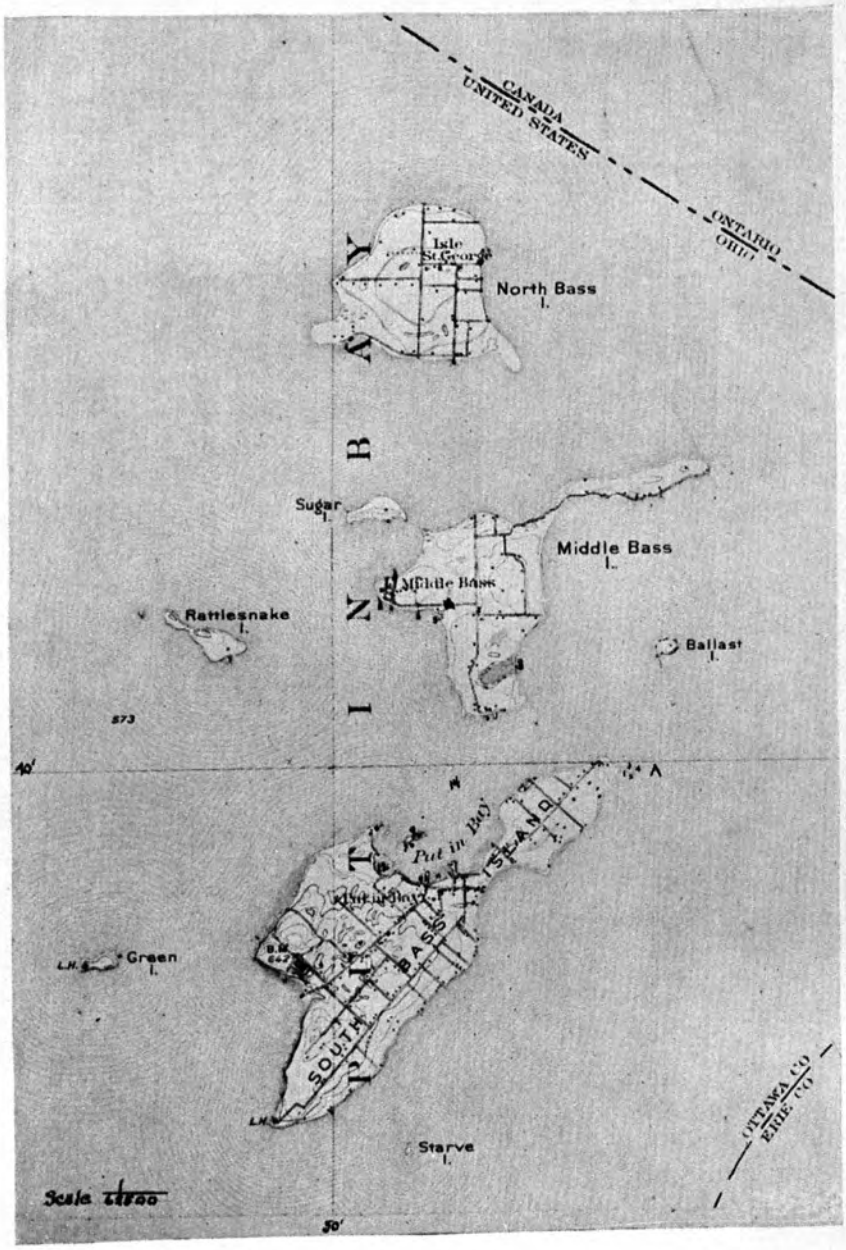
CANADA
UNITED STATES
ONTARIO
OHIO
Isle St. George
North Bass I.
Sugar I.
Middle Bass I.
Middle Bass
Rattlesnake I.
Ballast I.
573
40'
Put in Bay
Put in Bay
B.M. 647
Green I.
L.H.
SOUTH BASS ISLAND
Starve I.
OTTAWA CO
ERIE CO
Scale 1:200
30'

FIGURE 1

QL 430.4
D43

THE OHIO STATE UNIVERSITY
THE FRANZ THEODORE STONE LABORATORY
CONTRIBUTION No. 8

AQUATIC GASTROPODS OF THE BASS ISLAND REGION OF LAKE ERIE

By

CLYDE AVERY DENNIS, B.S., M.S., Ph.D.
Tusculum College, Greeneville, Tennessee

OHIO STATE UNIVERSITY
1928

TABLE OF CONTENTS

	Page
Introduction	1
Method	1
Description of Snails	3
Description of Stations and Their Snail Population	4
Distribution of Snails by Stations	23
Discussion of Factors Determining Distribution	23
Optimum Conditions for Each Species	32
Summary	33
Literature Cited	34

ILLUSTRATIONS

Fig. 1. Map of Bass Island Region, Frontispiece

Figs. 2 to 11 and 13 to 16. Halftones of Stations, and Diagrams of Gradients

Fig. 12. Map of Catawba Island

AQUATIC GASTROPODS OF THE BASS ISLAND REGION OF LAKE ERIE*

CLYDE AVERY DENNIS, B.S.

INTRODUCTION

This problem was begun at the Franz Theodore Stone Laboratory in August, 1927, and continued during the winter and spring quarters of 1928 at Ohio State University at Columbus. It is essentially a survey of the snails of the Bass Island region of Lake Erie with reference to their ecology.

A similar but more extensive work has been done by Frank Collins Baker for Oneida Lake, New York, and by A. D. Robertson for the Georgian Bay district. No work of this kind has been done in Lake Erie. The Bass Islands furnish an excellent location for a problem of this nature, being situated, as they are, several miles from the mainland, thus affording mid-lake environment.

The work was undertaken at the suggestion of Dr. F. H. Krecker to whom the writer is greatly indebted for his helpful suggestions and criticisms. I also wish to thank Mr. Bryant Walker of Detroit for the identification of some of the snails.

METHOD

The first step in the solution of the problem was the selection of a number of stations from which material could be collected. In the selection of these stations special attention was paid to their ecological nature and position. The aim was to select a station for each typical ecological situation. The first four stations were located on Buckeye Island. Although only a few rods apart they were four distinct ecological situations; they represented the following ecological conditions: first, a stony shore; second, eroding rocky shore; third, an approaching pond condition; fourth, a very rocky shore. The fifth station was a rubble beach on Middle Bass Island; the sixth was on the bay side of Alligator Bar on Gibraltar Island and represented a protected stony shore; the seventh was on the lake side of Alligator Bar and was an exposed stony shore.

* A thesis presented for the degree of Master of Science, The Ohio State University.

Station eight was a sandy shore with rocky shore line on Middle Bass Island; nine was on the lake side of Gibraltar Island and represented an exposed cliff shore line; ten was a sand beach at East Harbor, Catawba Island; eleven was an open pond at East Harbor; twelve was an approaching pond condition at Squaw Harbor, South Bass Island; thirteen was Fisher's Pond, representing an old pond, on Middle Bass Island; and fourteen was a dredge in the steamboat channel to the east of Gibraltar Island.

At each of these stations certain zones were established on the basis of depth of water. They were generally of the same size (1 sq. ft. approximately), so as to form a criterion for a quantitative count of the snails in each station.

At each station the wave action, gradient, and exposure to storm were taken into account. For each zone the following points were considered: distance from shore, area studied, nature of the substratum, and vegetation, if any, temperature of the water, depth of the water, transparency of the water, and the pH. or hydrogen-ion concentration of the water. In those stations with rocky substratum several rocks were measured and the average calculated. The number of snails in each zone was counted. Each of the stations was then checked against other locations as near like it as possible and comparisons made.

The depth of the water was taken by an accurate measuring rod and the distance from shore measured by a steel tape. A La Mott Hydrogen Ion testing set, model 30, was used for the pH. The collecting in deep water was done either by diving, by bottom sampler, or by a small dredge, pulled by a motor boat.

From time to time terms will be used in this paper which unless made clear at the outset may confuse the mind of the reader, and for this reason they will be explained now. A rubble beach is one with a substratum of small rounded stones; the stones have all been worn smooth by their constant grinding together as a result of much wave action; these stones will average ¾ inch across.

An eroding rocky shore is a shore where the substratum is of flat, smooth rock with an occasional crevice, but with very few loose stones on it.

A stony shore is one that has a bottom of stones which will not average more than 4 inches across; these stones are not rounded as the rubble and may be of any shape.

A rocky shore is one where the substratum consists of rocks averaging greater than 4 inches across (54 cu.in.)

The temperature of the water will always be expressed in the centigrade system.

DESCRIPTIONS OF THE SNAILS

1. *Campeloma subsolidum* Anthony

   Shell: Very solid, large, globose, more or less malleated; color light horn or light green; surface polished; some growth lines which roughen the shell to some extent; whorls six to seven.

2. *Campeloma rufum* Haldeman

   Shell: Large, globose, thick but not heavy; color olive green to light horn, beneath the epidermis the shell is pinkish or reddish and the apex is reddish; surface shining, polished, smooth; lines of growth numerous; whorls five and one-half to six and one-half.

3. *Pleurocera acuta* Rafinesque

   Shell: Elevated, acute, turreted on the upper whorls; color yellowish horn, olivaceous or greenish horn, encircled by a yellowish band just below the suture, and with two purple bands encircling the whorls just above and below a line drawn about the center of the whorl; apex sharp; whorls ten to eleven.

4. *Succinea higginsia* Bland

   Shell: Thin, transparent, color light horn; aperture three-fourths the length of the shell; whorls three; surface covered with fine lines of growth.

5. *Planorbis trivolvis* Say

   Shell: Sinistral, discoidal, flat, carinate above, subcarinate below; color brownish or chestnut horn; surface shining; lines of growth numerous; whorls four.

6. *Goniobasis livescens* Menke

   Shell: Varying from elongate to ovate; color varying from bluish flesh to light corneous, sometimes greenish, and sometimes with two dark bands; whorls seven to nine; dextral.

7. *Physa ancillaria magnalacustris* Walker

   Shell: Small, polished; sinistral; whorls four to four and one-half, color bright horn.

8. *Limnea humilis* Say

   Shell: Transparent to translucent, ovate; conic; color light horn, sometimes reddish; surface shining; whorls five.

9. *Planorbis parvus* Say

   Shell: Small, dextral, depressed with a well rounded periphery; color bright horn to jet black; surface shining in the bright-colored ones but dull in the black ones; whorls four; all whorls in the same plane.

10. *Limnea woodruffi* Baker

    Shell: Ventricose, very much inflated, solid; color greenish horn or olivaceous; surface shining, growth lines distinct; whorls three to four.

11. *Planorbis exacutus* Say

    Shell: Dextral, very much depressed; surface shining; whorls four; peristome thin, acute.

12. *Valvatia tricarinata* Say

Shell: More or less turbinate, color varying from dirty white to horn-colored; surface shining; whorls three and one-half, strongly carinated.

13. *Amnicola limosa* Say

Shell: Conic, nearly as broad as high; color light or dark brown, surface shining; whorls four to five, more or less inflated.

13. *Ferrissia fusca* Adams

Shell: Conic, small, fragile; apex prominent, elevated, rounded; color greenish horn.

15. *Ferrissia parallela*

Shell: Conic, small; color greenish horn, apex rounded.

Description of Stations and Their Snail Population

Station 1. Buckeye Island

Figure 1, No. 1

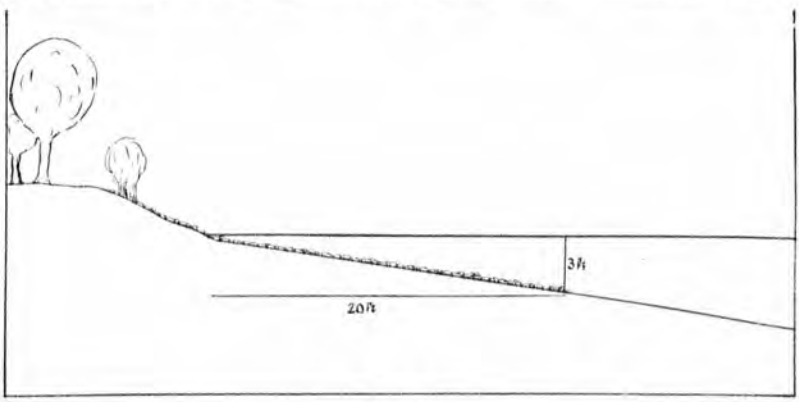

Figure 2

A Rocky Shore

Buckeye Island is really an extension of the eastern end of South Bass Island as it is separated from the larger island by only a few feet of shallow water.

Station 1 is protected on the northwest by the bar which connects Buckeye with South Bass Island, on the east and southeast it is protected by a spur of Buckeye Island, to the south and southwest the only protection is the mainland, three miles away, and in case of heavy gales from these directions fairly large waves do reach this station; this condition would occur only rarely, however. As a whole the station is very well protected.

The substratum was composed of stones averaging thirty cubic inches. The stones were all covered with algae. There was some submerged vegetation in zone 2 and some sediment in zones 2, 3, and 4.

The gradient at this station is rather gradual, being 3 feet in 20.

Buckeye Island, Station 1

Zone	Area	Distance from shore	Sub-stratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Rocky	24C.	2 in.	7.8	*Physa ancillaria magnalacustris* 151
							Limnea humilis Say 110
2.....	1 sq. ft.	8 ft.	Rocky	24C.	6 in.	7.8	*Goniobasis livescens* 21
3.....	1 sq. ft.	15 ft.	Rocky	23C.	2½ ft.	7.8	*Goniobasis livescens* 20
							Physa ancillaria 1
							Limnea humilis 1
4.....	1 sq. ft.	25 ft.	Rocky	23C.	3½ ft.	7.8	*Goniobasis livescens* 10

The substratum of these zones as has been stated was very rocky. The rocks were completely covered on the top and sides with algae. At zone 2 there was submerged vegetation, which was very short and was kept in constant motion by the waves.

Station 2. Buckeye Island

Figure 1, No. 2

An Eroding Rocky Shore

This station faces to the southeast. It is somewhat protected to the southwest but to the south and southeast there is no protection and during storms and stiff winds from the south and east the waves break violently on this shore.

The substratum is of flat, solid rock with a few crevices. There are a few small boulders and stones lying near the shore line and these as well as the solid rocks are covered with algae.

The gradient here is very gradual, being only 42 inches in one hundred feet.

At the time the observations were made there was a moderately strong wind from the southeast and the waves were breaking violently ten feet from shore.

BUCKEYE ISLAND, STATION 2

Zone	Area	Distance from shore	Substratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Rocky	22C.	1 in.	7.8	No snails
2.....	1 sq. ft.	2 ft.	Rocky	22C.	6 in.	7.8	*Physa ancillaria* 28
							Limnea humilis 44
							Goniobasis livescens 1
3.....	1 sq. ft.	10 ft.	Rocky	22C.	9 in.	7.8	*Goniobasis livescens* 3
4.....	1 sq. ft.	20 ft.	Rocky	22C.	16 in.	7.8	*Goniobasis livescens* 9
5.....	5 sq. yds.	40 ft.	Rocky	22C.	29 in.	7.8	*Goniobasis livescens* 9
6.....	5 sq. yds.	100 ft.	Rocky	22C.	42 in.	7.8	*Goniobasis livescens* 20
7.....	2 sq. ft.	500 ft.	Stony	22C.	14 ft.	7.8	*Goniobasis livescens*—many

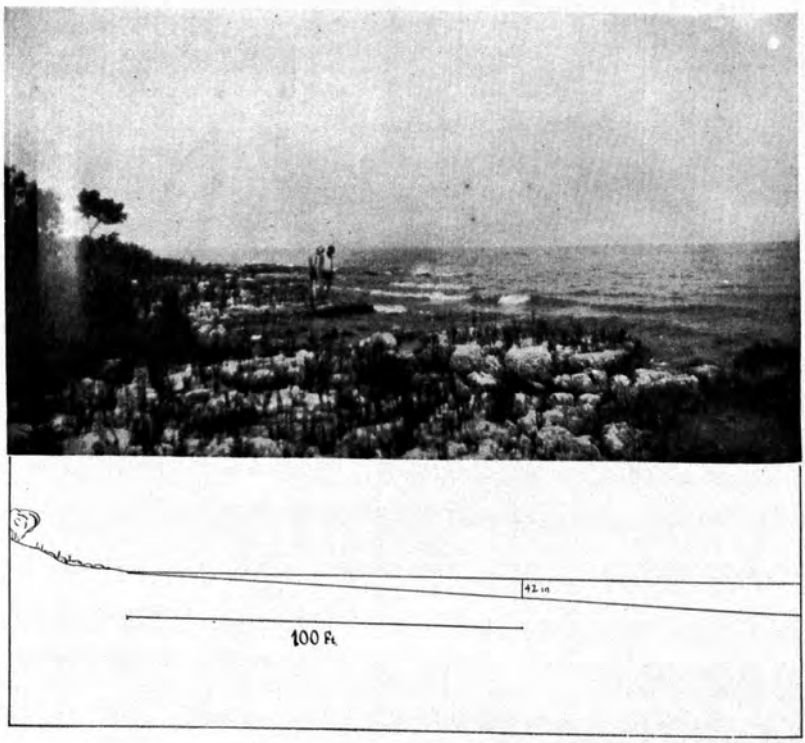

FIGURE 3

The substratum of the first, third, fourth, and fifth zones was smooth solid rock, but in the sixth and seventh the floor had been broken up until there were small stones in considerable numbers, especially so in the seventh zone. This, I think, accounts for the increase in number of snails in this station over the

others. No snails were found in the first zone, no doubt due to the terrific smashing of the waves and to the nature of the substratum which allowed no chance for clinging or burrowing.

STATION 3. BUCKEYE ISLAND
Figure 1, No. 3

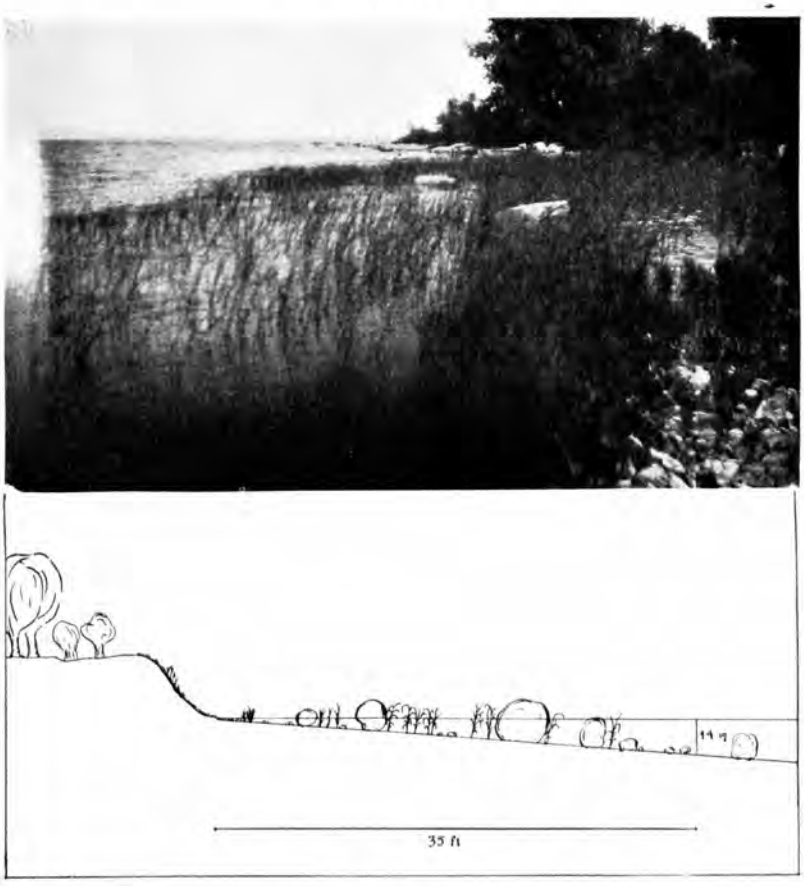

FIGURE 4

AN APPROACHING POND CONDITION

This station is on the north side of Buckeye Island. It is well protected on the north and northeast by Ballast and Middle Bass Island, on the east by an extension of Buckeye Island and on the west and northwest by Middle Bass and South Bass Islands. On the whole it is very well protected.

There is sediment here that covers all but the larger rocks and boulders. The vegetation has secured a good foothold. It consists of some *Castalia odorata, Typha latifolia,* and *Scirpus.* The vegetation is fairly thick at shore line and gradually thins out until at the 30-foot mark it stops. The rocks that are not covered with sediment are entirely covered with algae. The gradient is very gradual as shown by the diagram and picture; it is 14 inches in 35 feet.

There is practically no wave action at shore line as the waves break 100 feet from shore.

BUCKEYE ISLAND, STATION 3

Zone	Area	Distance from shore	Substratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Rocky	27C.	2 in.	7.8	*Physa ancillaria magnalacustris* 21 *Limnea humilis* 117 *Planorbis parvus* Say 4
2.....	1 sq. ft.	4 ft.	Rocky with Sediment	27C.	4 in.	7.8	*Limnea humilis* 5 *Physa ancillaria* 1
3.....	5 sq. ft.	30 ft.	Rocky	27C.	14 in.	7.8	*Goniobasis livescens* Numerous
4.....	5 sq. ft.	150 ft.	Rocky	26½C.	20 in.	7.8	*Goniobasis livescens* Numerous
5.....	5 sq. ft.	800 ft.	Rocky	26C.	12 ft.	7.8	*Goniobasis livescens* 6

At zone 1 the substratum consisted of rocks partially covered with sediment and rooted vegetation. At zone 2 the rocks were almost entirely covered with sediment and those which were not were covered with algae. From zone 2 to 3 the area was searched closely and only one snail was found *(Physa ancillaria)*. This area was in a growth of reeds; beyond the reeds, however, Goniobasis was found in abundance clinging to the sides and tops of rocks.

STATION 4. BUCKEYE ISLAND
Figure 1, No. 4

A VERY ROCKY SHORE

Station 4 is located on the east point of the island. It is protected on the north by Ballast and Middle Bass Islands but to the east and south it is completely exposed, and during high winds and storms the waves break near the shore line with terrific force. The shore line itself is pretty well protected from the direct smashing effect of the waves by the presence of large boulders near the shore.

The substratum is very rocky, some of the rocks are several cubic feet in volume.

The gradient here is 3 feet in 30, which is steeper than in the other stations on Buckeye Island.

BUCKEYE ISLAND, STATION 4

Zone	Area	Distance from shore	Substratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Rocky	22C.	2 in.	7.6	*Physa ancillaria magnalacustris* 151 *Limnea humilis* 36
2.....	1 sq. ft.	20 ft.	Rocky	22C.	2 ft.	7.6	*Goniobasis livescens* 4
3.....	1 sq. ft.	30 ft.	Rocky	22C.	30 in.	7.6	*Goniobasis livescens*—many

Limnea humilis and *Physa ancillaria* were found from the shore line to a distance of 8 feet from shore and in water up to 10 inches in depth. The substratum was very rocky with large boulders close to the shore line, and on these *Goniobasis livescens* were clinging in great numbers. Goniobasis could also be found with the aid of a bottom sampler at a distance of a thousand feet from shore in water 6 to 14 feet deep.

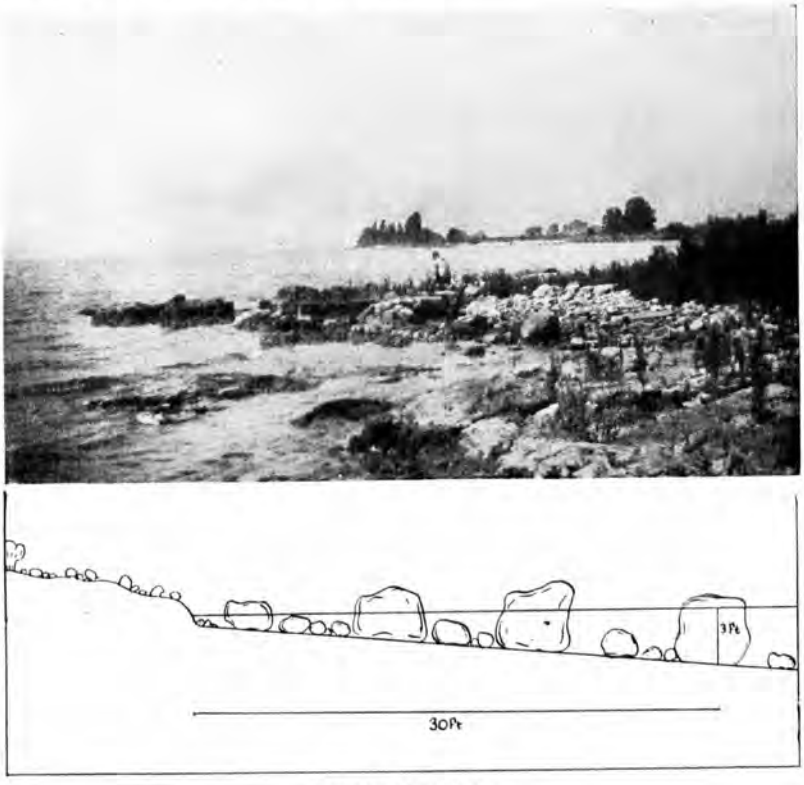

FIGURE 5 (Station 4)

STATION 5. MIDDLE BASS ISLAND
Figure 1, No. 5

A RUBBLE BEACH (GRAVEL)

This station is located on the west side of Middle Bass near a point where the shore makes a sharp turn to the west. The wave action is greatly reduced by this curve in the shore, but the station is exposed freely to the waves from the west and northwest. Rattlesnake Island, which is two miles due west of this station, helps slightly to reduce the amount of exposure from the west, but during high winds from the west and northwest there is considerable wave action.

The substratum is rubble. The gradient is steep, 5 feet in 30. This allows the waves to break very close to shore line and the result is a constant grinding of the rubble. Large waves carry it for some distance and throw it high upon

the beach, and even the very small waves shift it back and forth. There is practically no sediment or vegetation.

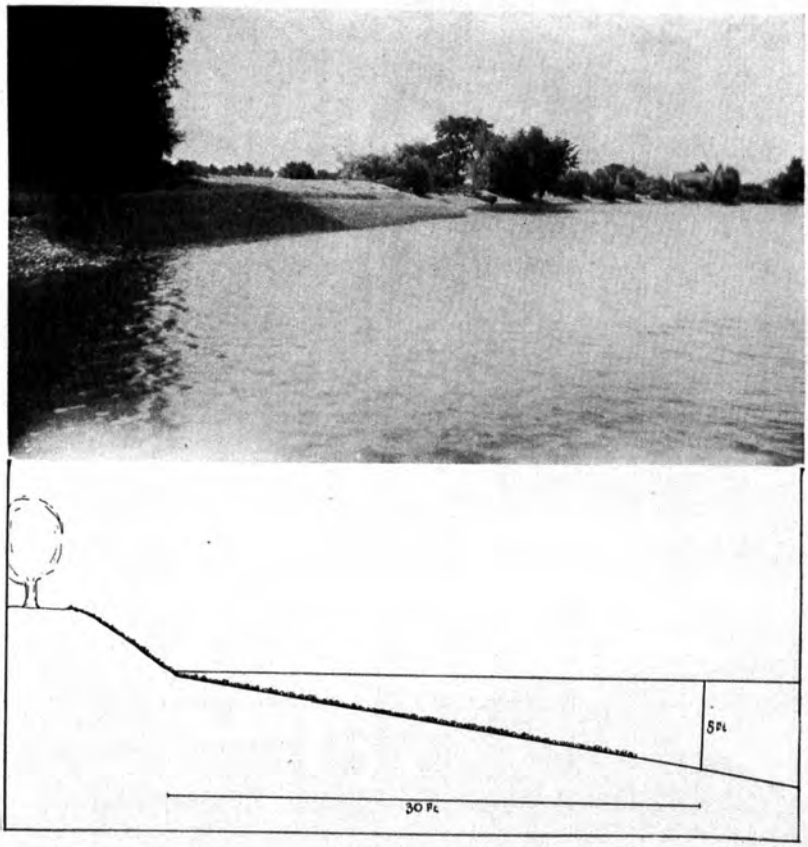

FIGURE 6

MIDDLE BASS ISLAND, STATION 5

Zone	Area	Distance from shore	Substratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Gravel	22C.	1 in.	7.8	No. Snails
2.....	1 sq. ft.	5 ft.	Gravel	22C.	18 in.	7.8	No Snails
3.....	1 sq. ft.	20 ft.	Gravel	22C.	3½ ft.	7.8	No Snails
4.....	1 sq. ft.	30 ft.	Gravel	22C.	5 ft.	7.8	No Snails
5.....	5 sq. ft.	50 ft.	Rocky	21C.	6 ft.	7.8	*Goniobasis livescens* 12

Goniobasis were found with the bottom sampler at a depth of seven feet from shore but beyond this depth they were absent, due, I think, to the fact that at this depth the nature of the substratum changed suddenly from rocks to a very fine sand.

Station 6. Gibraltar Island (Figure 1, No. 6)

A Well-protected Stony Shore

This station is located on the east or bay side of Alligator Bar. This bar extends south from Gibraltar Island into Put-in-Bay; it is about 80 feet long and 30 feet wide at the widest point. The station is protected on all sides and the water is quiet except in very severe storms.

The substratum is composed of rocks averaging 48 cubic inches. There is some sediment and the rocks are covered with algae. There is considerable submerged vegetation (Cladophora) starting at the 15-foot level.

The gradient here is rather steep, 5 feet in 20.

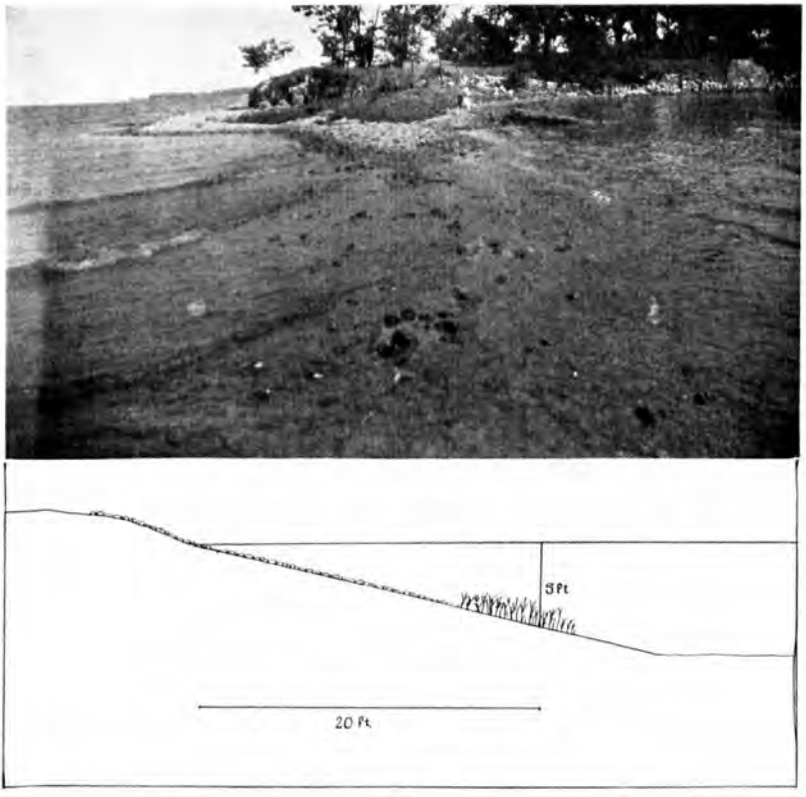

Figure 7

Gibraltar Island, Station 6

Zone	Area	Distance from shore	Substratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Rocky	23C.	1 in.	7.8	*Physa ancillaria* 18
							Limnea humilis
2.....	1 sq. ft.	10 ft.	Rocky	23C.	2½ ft.	7.8	*Goniobasis livescens* 3
							Physa ancillaria 2
							Limnea humilis 1
3.....	1 sq. ft.	20 ft.	Muddy	23C.	3 ft.	7.8	No Snails

Goniobasis were very numerous at a distance of 12 feet from shore and in a depth of 2½ feet. The substratum of the bay consists of mud which supports great quantities of submerged vegetation.

Station 7. Gibraltar Island
Figure 1, No. 7

An Exposed Stony Shore

This station is just across the bar from station 6. It is partly protected from the open lake by bars and a projection of Gibraltar and yet during storms from the north and northwest waves break with considerable force near the shore line. The rocks near the shore line are rolled about during storms.

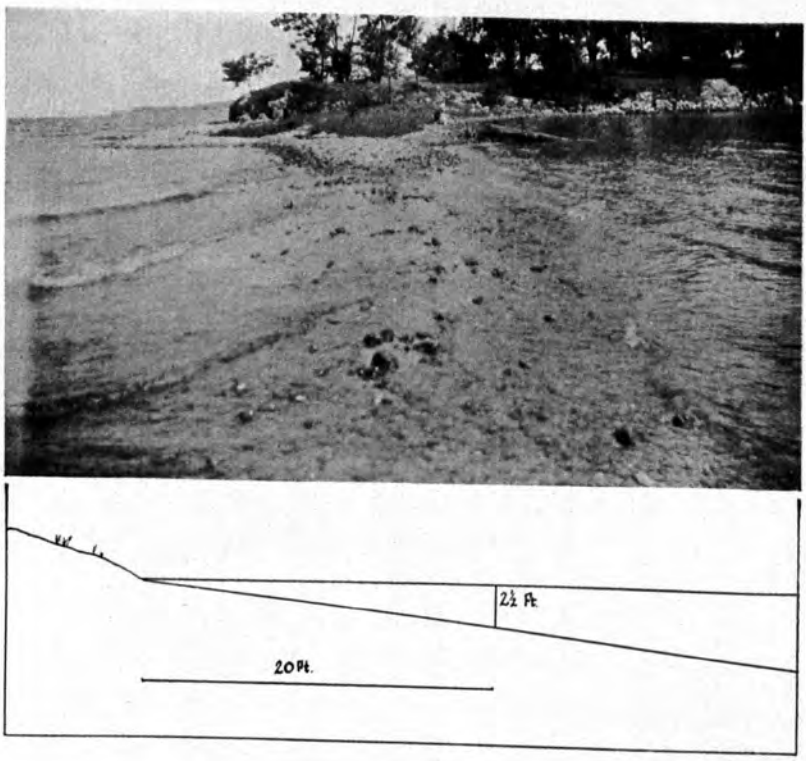

Figure 8

The substratum is composed of stones which range in size from pebbles to those 10 inches across. In contrast to those on the opposite side of the bar they are smooth and are not covered with algae. There is no sediment.

The gradient which is about 2½ feet in 20 is much more gradual than that on the opposite side of the bar.

The rocks that make up the substratum of the first 4 zones range in size from coarse gravel to small boulders.

GIBRALTAR ISLAND, STATION 7

Zone	Area	Distance from shore	Substratum	Temp. of water	Depth of water	pH	Snails Species and No.	
1.....	1 sq. ft.	At shore	Rocky	24C.	1 in.	8.0	*Physa ancillaria*	5
2.....	1 sq. ft.	10 ft.	Rocky	24C.	14 in.	8.0	No Snails	
3.....	1 sq. ft.	15 ft.	Rocky	24C.	2 ft.	8.0	*Goniobasis livescens*	23
4.....	5 sq. ft.	25 ft.	Gravel and Sediment	24C.	6 ft.	8.0	No Snails	

STATION 8. MIDDLE BASS ISLAND
Figure 1, No. 8

A SAND BEACH WITH ROCKY SHORE LINE

This station is a sandy shore on Middle Bass Island. It is fairly well pro-

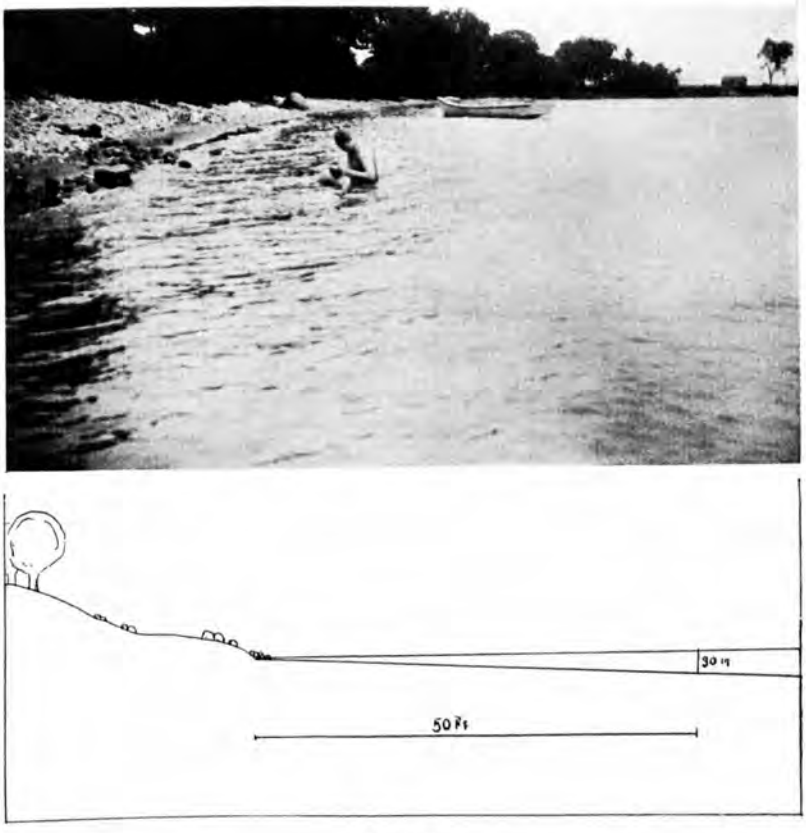

FIGURE 9

tected on all but the east side; in case of storm from this direction the waves come in with some force.

The substratum is of fine sand except at shore line where, for a width of

two feet, there are rocks which are partly covered with sand. These rocks will average 50 cubic inches in size.

The gradient here is very gradual, only 30 inches in 50 feet.

At the time the observations were made the day was clear and there was a light wind from the east. There were gentle waves coming in and every one stirred up the sand which settled quickly into small ridges. The water cleared again before the next wave came in.

MIDDLE BASS ISLAND, STATION 8

Zone	Area	Distance from shore	Sub-stratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Sand and Rocks	22C.	2 in.	7.8	*Physa ancillaria* 25 *Limnea humilis* 71

From zone 1 out to a distance of 200 feet from shore, the substratum was of fine sand and here there were no snails found. At a distance of 200 feet from shore the substratum was rocky; this region was observed but no snails were found.

STATION 9. GIBRALTAR ISLAND

Figure 1, No. 9

ROCKY SHORE WITH STEEP GRADIENT

This station is on the north side of Gibraltar Island. The shore line is at the foot of a cliff some 40 or 50 feet high. There is no protection from the open lake to the north and large waves strike the foot of the cliff with great force. There are very few times when the waves are not breaking at the foot of this cliff.

The substratum is made up of stones which vary in size from large gravel to huge boulders. All are bare as the action of the waves prohibits the growth of algae. The smaller stones near the shore line are rolled around a great deal by the wave action.

The gradient at this station is very steep, being 7 feet in 25.

GIBRALTAR ISLAND, STATION 9

Zone	Area	Distance from shore	Sub-stratum	Temp. of water	Depth of water	pH	Snails Species and No.
1.....	1 sq. ft.	At shore	Rocky	21C.	3 in.	8.0	No Snails
2.....	1 sq. ft.	5 ft.	Rocky	21C.	2 ft.	8.0	*Goniobasis livescens* 1
3.....	1 sq. ft.	10 ft.	Rocky	21C.	3 ft.	8.0	*Goniobasis livescens* 3
4.....	1 sq. ft.	20 ft.	Rocky	21C.	5 ft.	8.0	*Goniobasis livescens* 6
5.....	1 sq. ft.	20 ft.	Rocky	21C.	5 ft.	8.0	*Goniobasis livescens* 3

Goniobasis were found at a depth of seven feet with the aid of a bottom sampler. The depths beyond seven feet were searched with the sampler but no snails were found. The substratum was very rocky; the rocks were of all sizes, from gravel to large boulders weighing several tons. It was very difficult to trap snails on a substratum of that type and this may account for not getting any snails beyond the 7-foot depth.

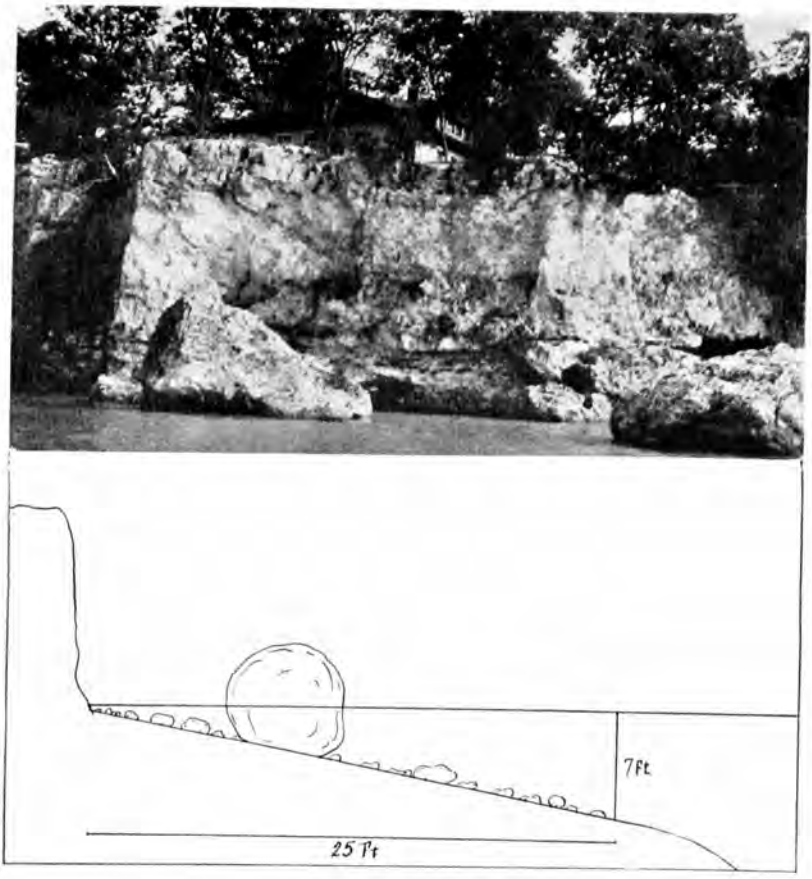

FIGURE 10 (Station 9)

STATION 10. EAST HARBOR—CATAWBA ISLAND
Figure 12, No. 10

A SAND BEACH

Station 10 is a sand beach. The sand is very fine and is constantly shifting and settles in long ridges paralleling the shore. The station is protected in all directions except to the east. The gradient is so gradual that the waves break a long way from shore but they do come clear to shore line and each one causes a shifting of the sand.

The gradient here is very gradual; at a distance of 100 feet from shore it is only 3½ feet deep, and one can walk out nearly a quarter of a mile.

The last zone was situated between the shore and a sand bar which was located at a distance of 20 feet from shore. This bar during calm weather was above water about 4 inches; it was 80 feet long and 10 feet wide. Between this bar and the shore the water was 18 inches deep in the deepest place. The bottom was of smooth sand in contrast to the bottom elsewhere which was in ridges due to the shifting of the sand with the waves. The snails found in this location were moving about in the sand making long trails, some were lying on the

surface and others were completely buried and could only be located by tracking them and digging at the end of the trail they made while moving.

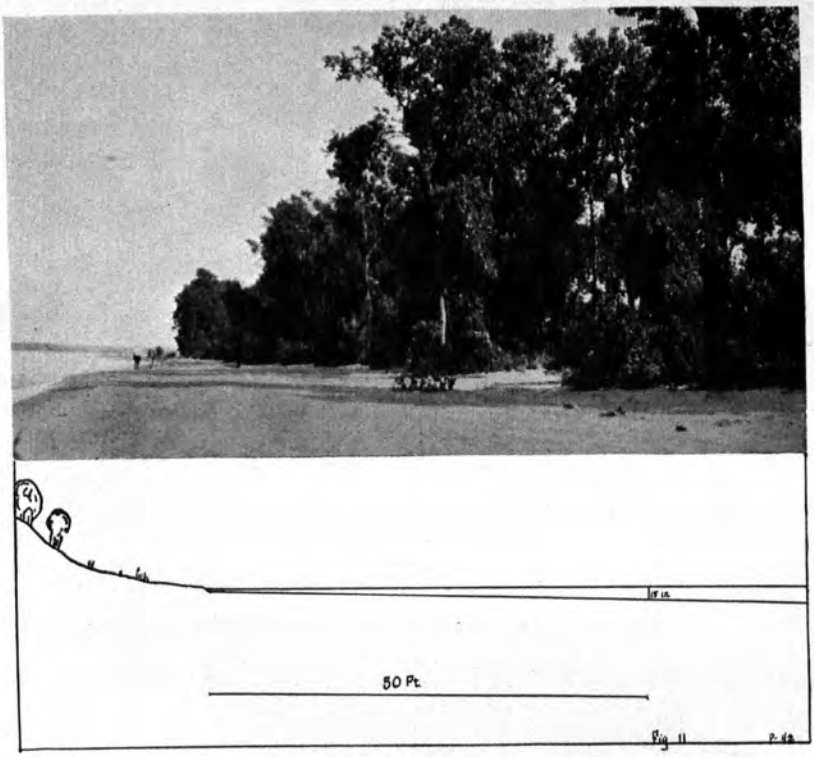

FIGURE 11

SAND BEACH, EAST HARBOR, STATION 10

Zone	Area	Distance from shore	Sub-stratum	Temp. of water	Depth of water	pH	Snails Species and No.	
1.....	1 sq. ft.	At shore	Sand	25C.	½ in.	7.8	No Snails	
2.....	1 sq. ft.	10 ft.	Sand	25C.	4 in.	7.8	No Snails	
3.....	1 sq. ft.	30 ft.	Sand	25C.	8 in.	7.8	No Snails	
4.....	1 sq. ft.	50 ft.	Sand	25C.	15 in.	7.8	No Snails	
5.....	1 sq. ft.	90 ft.	Sand	25C.	3 ft.	7.8	No Snails	
6.....	8 sq. yds.	15 ft.	Sand	25C.	9-18 in.	7.8	*Pleurocera acuta*	22
							Goniobasis livescens	3

STATION 11. EAST HARBOR—CATAWBA ISLAND
Figure 12, No. 11

AN OPEN POND

This station is a harbor about 1¾ miles long by ½ wide with the characteristics of a pond. It has but one opening to the lake; this opening is about 40 feet wide and of course allows very few waves to enter. The harbor extends for a mile and a half eastward from the mouth.

The depth of this harbor is 10 feet deep near the opening to the lake, but the average depth of the channel worked was 3½ feet.

A great many kinds of vegetation border the channel, *Castalia odorata*, *Typha angustifolia*, etc. In the channel, is a great deal of submerged vegetation.

The substratum near the opening to the lake is sand but as one moves away from the inlet the substratum gradually changes to muck.

The temperature of water at this station is quite variable as one moves away from the lake, due, no doubt, to the quietness of the water and the presence of so much vegetation.

FIGURE 12

Zone 1 was at the entrance. Waves from the lake reached this point. The substratum is sand with an occasional rock. The gradient is very steep (nearly perpendicular). The seiche is responsible for a current that flows back and forth, but this is not strong enough to cause any great movement of the sand along the edge of the channel at least.

Zone 2 was in the reeds 100 yards from the mouth of the harbor. The water is always quiet at this point except for the movement of the seiche which is very gentle. The substratum is of muck 5 or 6 inches deep. The vegetation is cat-tails (Typha).

Zone 3 was just across the channel from zone 2. The substratum was of muck with an occasional sand patch, on these patches were found the Pleurocera and Goniobasis.

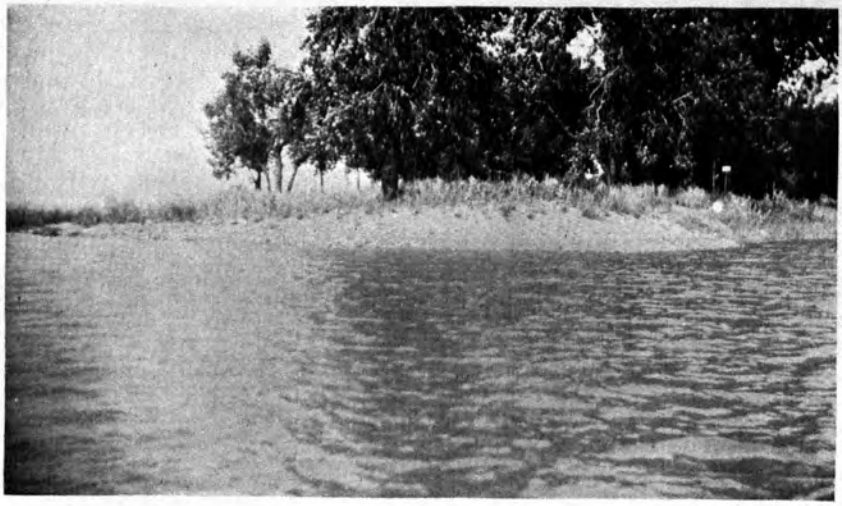

FIGURE 13 (Station 11, Zone 1)

EAST HARBOR, CATAWBA ISLAND, STATION 11

Zone	Area	Distance from shore	Substratum	Temp of water	Depth of water	pH	Snails Species and No.	
1.....	1 sq. ft.	4 ft.	Sand	22C.	2 ft.	7.8	*Goniobasis livescens*	5
							Pleurocera acuta	1
							Campeloma subsolidum	3
2.....	1 sq. ft.	10 ft.	Muck	20C.	1 ft.	7.6	*Campeloma subsolidum*	1
3.....	1 sq. ft.	3 ft.	Muck and Sand	24C.	18 in.	7.6	*Goniobasis livescens*	2
							Pleurocera acuta	3
							Campeloma subsolidum	5
							Planorbis trivolvis	2
4.....	4 sq. yds.	300 ft.	Muck	25C.	15 in.	7.5	*Campeloma subsolidum*	4
							Planorbis trivolvis	1
5.....	4 sq. yds.	250 ft.	Muck and Sand	27C.	18 in.	7.4	*Goniobasis livescens*	4
							Campeloma subsolidum	5
							Amnicola limosa	20
							Ferrissia parallela	3
							Ferrissia fusca	4

Zone 4 was an isolated clump of cat-tails about one-half mile from the mouth of the harbor; the substratum was of muck several inches deep and the water was very quiet.

Zone 5 was in a growth of lily pads about a mile from the opening of the harbor. The substratum was muck with an occasional sand patch. On the bottom the Goniobasis and Campeloma were found and on the lower side of the lily pads were found the Amnicola and Ferrissia.

FIGURE 14 (Station 11, Zone 5)

SQUAW HARBOR, SOUTH BASS ISLAND, STATION 12

Zone	Area	Distance from shore	Sub-stratum	Temp. of water	Depth of water	pH	Snails Species and No.	
1.....	1 sq. ft.	At shore	Rocky	22C.	5 in.	7.8	*Limnea humilis*	3
							Physa ancillaria	3
							Succinea higginsia	5
							Planorbis trivolvis	4
							Goniobasis livescens	10
2.....	1 sq. ft.	20 ft.	Muck submerged vegetation	22C.	18 in.	7.8	No Snails	
3.....	1 sq. ft.	300 ft.	Rocky	22C.	2½ ft.	7.8	*Goniobasis livescens*	28
4.....	1 sq. ft.	100 ft.	Muck	22C.	3 ft.	7.8	*Amnicola limosa*	8
							Limnea humilis	3
							Ferrissia fusca	4
							Ferrissia parallela	5
							Physa ancillaria	1
							Planorbis parvus	8
5.....	1 sq. ft.	20 ft.	Muck	22C.	8 in.	7.6	*Ferrissia fusca*	3
							Ferrissia parallela	2
							Amnicola limosa	8

Station 12. Squaw Harbor—South Bass Island

Figure 1, No. 12

An Approaching Pond Condition

At station 12 conditions approach those of a pond. The situation is on the north side of South Bass Island well protected on all sides and with the water consequently always quiet. The water, however, is constantly changed due to the large opening to the lake. There is some emergent vegetation and a great amount of submerged vegetation.

The gradient at the bank is very steep due to a stone fill used in the construction of a road; a few feet beyond the water line, however, the bottom is almost level for a hundred feet.

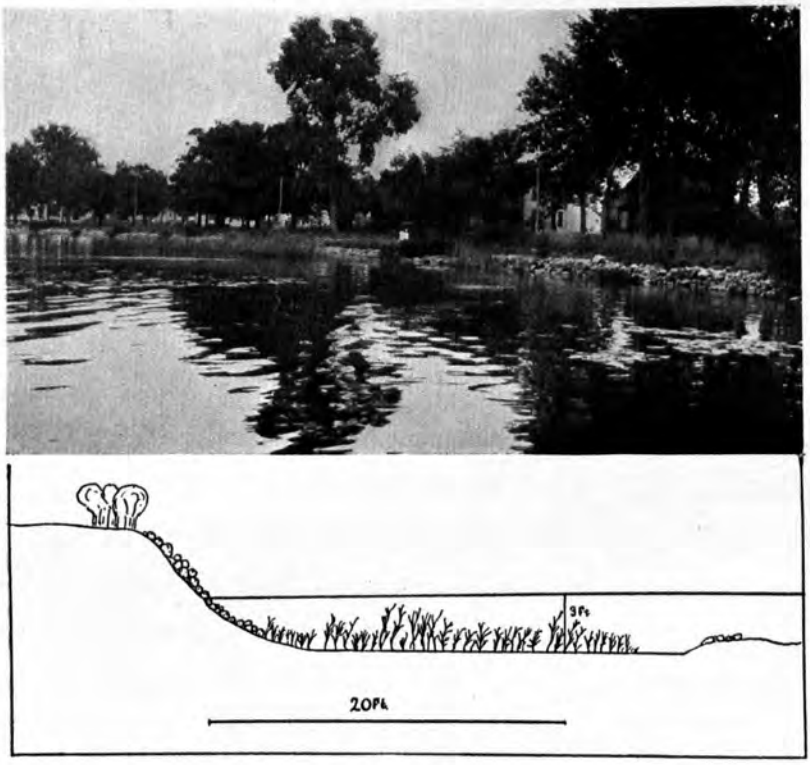

Figure 15

The temperature of the water is about that of the lake as the effect of the sun on the quiet water is offset by the shade of the vegetation.

Zone 1 was at water line and the snails were found clinging to the rocks which made up a wall for the support of a road. The water was only an inch or two deep on some of the rocks and a foot deep on others.

Zone 2 was in dense submerged vegetation and the substratum was of muck and very soft.

Zone 3 was a bar about 300 ft. from shore; it was pretty well exposed to the lake to the north and east and in time of heavy storms fairly large waves reached this bar. The substratum was made up of stones ranging in size from coarse gravel to small boulders.

Zone 4 was in a patch of water-lily pads about 100 feet from shore. The substratum was rocky. This location was well protected from the waves of the lake by the bar mentioned in zone 3. The water was roily.

Zone 5 was in a growth of reeds. The substratum was of muck and though thoroughly searched no snails were found. The snails mentioned in the table were found on the stems of the reeds.

Station 13. Fisher's Pond—Middle Bass Island

Figure 1, No. 13

An Old Pond

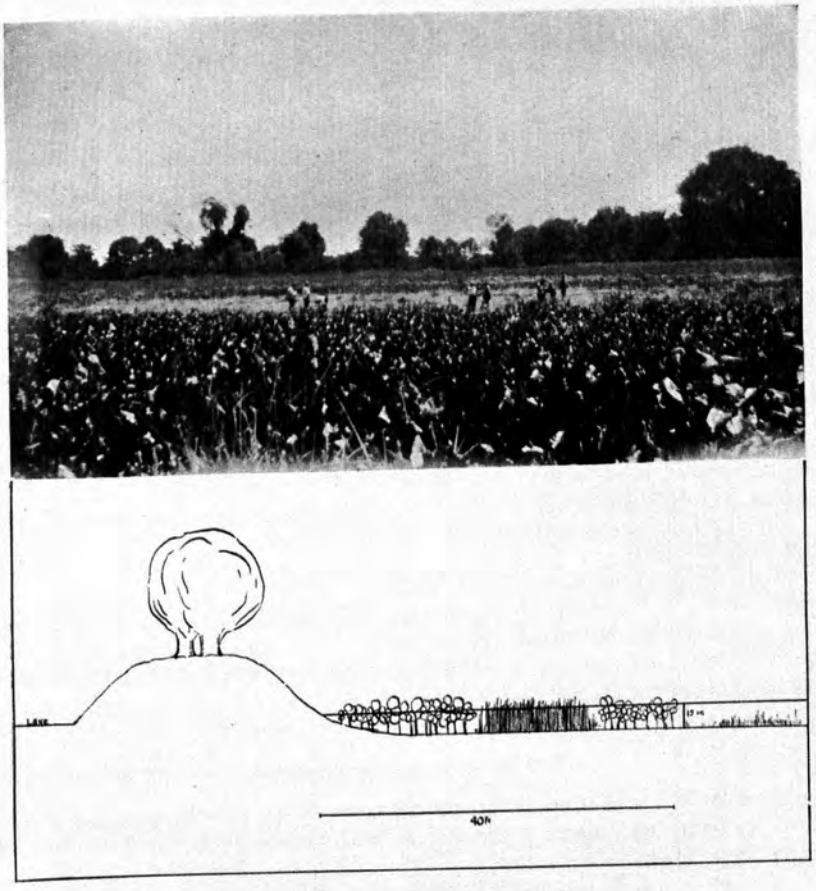

Figure 16

This station is a pond which is separated from the lake by only a gravel bank some 30 feet wide. It has evidently been separated from the lake for some time because there are several large willow trees growing on the bank and also because there is a layer of muck a foot thick in the pond.

As can be seen by the photograph and diagram of Figure 16, the vegetation is rank. Close to shore there is a belt of water lilies; this is followed by a dense growth of Sagittaria; beyond this is another belt of water lilies, which

thins out and stops near the middle of the pond to leave a small area of open water (with submerged vegetation) near the center.

The pond is about the same depth throughout; it is 12 inches deep at shore line and 15 at the center. The substratum is muck, except at shore line where it is gravel.

The temperature here is colder than in the lake (17 degrees) due to the great amount of vegetation.

FISHERS' POND, MIDDLE BASS ISLAND, STATION 13

Zone	Area	Distance from shore	Sub-stratum	Temp. of water	Depth of water	pH	Snails Species and No.	
1.....	1 sq. ft.	At shore	Muck	17C.	2 in.	7.4	*Planorbis trivolvis*	3
							Physa ancillaria	2
							Limnea humilis	4
							Planorbis parvus	2
							Planorbis exacutus	4
2.....	1 sq. ft.	20 ft.	Muck	19C.	4 in.	7.4	No Snails	
3.....	1 sq. ft.	50 ft.	Muck	18C.	5 in.	7.4	*Planorbis trivolvis*	2
							Physa ancillaria	1
							Limnea humilis	2
							Planorbis parvus	1
4.....	1 sq. ft.	100 ft.	Muck	21C.	6 in.	7.4	No Snails	

Zone 1 was at water line where there was a dense growth of water lilies. The substratum was muck. The snails were found in most cases clinging to the stem or the lower surface of the water lilies.

Zone 2 was in a dense growth of emergent vegetation (Scirpus) and no snails were found.

Zone 3 was in another belt of water lilies like that in zone 1. The conditions were the same except the water was 3 inches deeper in zone 3 than zone 1.

Zone 4 was in the middle of the pond where the muck was a foot deep and there was a dense growth of submerged vegetation. No snails could be found either on the bottom or vegetation.

STATION 14. LAKE CHANNEL

In order to determine at what maximum depth of water snails could be found, a dredge was taken in the steam boat channel between South Bass and Middle Bass Islands.

This was done by pulling a small dredge for some distance behind a motor boat.

The bottom was rocky with very little mud.

The water is from thirty to thirty-five feet deep here and the temperature at the bottom is two degrees colder than at the top (22 degrees C. at top, 20 degrees C. at bottom).

THE DISTRIBUTION AND POPULATION OF SNAILS BY STATIONS

SNAILS	STATIONS 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Goniobasis l.	51	*	*	*	12	3	23	..	13	3	11	38	..	1
Rhysa an.	152	28	22	151	..	20	5	25	..	..	..	3	3	..
Limnea humilis	111	44	122	36	..	21	..	71	..	..	..	6	6	..
Planorbis par.	..	..	4	..	..	..	..	..	..	..	..	8	3	..
Planorbis ex.	..	..	..	..	..	..	..	..	..	..	..	..	4	..
Pleurocera ac.	..	..	..	..	..	..	..	..	..	22	4	..	..	16
Campeloma ruf.	..	..	..	..	..	..	..	..	..	..	..	2	..	..
Campeloma sub.	..	..	..	..	..	..	..	..	..	..	18	..	..	..
Ferrissia fus.	..	..	..	..	..	..	..	..	..	..	4	7	..	..
Ferrissia par.	..	..	..	..	..	..	..	..	..	..	3	7	..	..
Planorbis tri.	..	..	..	..	..	..	..	..	..	..	3	5	8	..
Amnicola lim.	..	..	..	..	..	..	..	..	..	..	20	16	..	..
Valvatia tri.	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Limnea Woodruf.	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Succinea Higg.	..	..	..	..	..	..	..	..	..	..	..	5	..	..

* Very numerous. The numbers indicate the number of individuals in an area of 1 square foot.

DISCUSSION AND CONCLUSION

On examining the composite table it becomes at once apparent that certain species of snails are rather closely confined to certain habitats while others are widely distributed. *Limnea woodruffi* for instance was found in only one station while *Goniobasis livescens* was found in every station but two.

During the field work the conditions which appeared to be the most important were noted and an attempt will be made to explain the distribution in the light of this information. The conditions noted are as follows: Temperature, depth, pH, transparency of the water, nature of substratum and exposure to wave action, gradient, oxygen supply, and amount of vegetation. From the data collected it was found that apparently pH was not a factor in distribution in any case, and in only one species was transparency a factor, so these two conditions will be omitted in the following discussion.

To avoid confusion each species of snail will be considered separately.

Goniobasis livescens

Goniobasis livescens is the most widely distributed species of gastropod in the region, and leads in the number of individuals also.

This snail was found in all but two stations, station 8 (Sand Beach) and 13 (Fisher's Pond). The temperature in station 8 was 23 degrees centigrade and since this is the same as in several other stations where Goniobasis was numerous, it apparently is not a limiting factor in the distribution in this case. In station 13, however, the temperature was 17 degrees centigrade, which is four de-

grees lower than that at any of the stations where Goniobasis was found and there is a probability that this might be a limiting factor. The depth of water will not explain the absence of this snail from these two stations as their depth falls within the range of depth where Goniobasis were found. The absence of the snail in stations 8 and 13 is apparently not due to gradient because in the case of each of the two stations the gradient corresponds very closely to that of stations in which the snails were found. Presence or absence of vegetation cannot be a limiting factor for station 8 has no vegetation, station 9 has an abundance of vegetation. Goniobasis is thus found in abundance at stations both with and without vegetation. The oxygen supply is probably not the cause for the absence of this snail at station 8 since breakers occurred at this station frequently and the water was kept well stirred up; at station 13 there is an abundance of vegetation which would probably keep the oxygen content as high or nearly as high as that of the lake so it is probably not a factor here.

The data points to the fact that the wave action coupled with the nature of the substratum is the limiting factor in the distribuion of this snail. The exposure to wave action alone is probably not a limiting factor because in station 8 there is a moderate wave action and at station 13 there is no wave action at all, while Goniobasis was found in stations with all degrees of wave action and in quiet water. The lack of snails at station 8 is due to the nature of the substratum which is very fine sand which is constantly being shifted about by the waves. The snails are apparently not able to stand this; they were found, however, at Sand Beach on a fine sand substratum that was protected from the waves. At station 13 the substratum is of black muck and several other locations with the same substratum were visited and no Goniobasis were found. In East Harbor Goniobasis were found on small sand patches ½ mile from the mouth of the harbor, these sand patches were completely surrounded by muck but there was no Goniobasis on the muck. This looks as though muck was a barrier. Muck may be a barrier on account of its high acidity.

Physa ancillaria magnalacustris

Physa ancillaria was the second most widely spread of the gastropods in this region; it was found in all but 5 stations. It runs a close second to Goniobasis in number of individuals also.

Temperature apparently is not a factor in the distribution as the temperature of the stations where this snail is lacking falls within the range (21 degrees to 25 degrees centigrade) and Physa

were found in other locations at these temperatures. The presence or absence of vegetation has no influence since the snail was found where there was no vegetation and where there was a rank growth.

Exposure to wave action does appear to limit the distribution to some extent. In the case of severe wave action as at station 9, which is on the north side of Gibraltar Island, the force of the waves is so great that even this tight clinging snail is not able to maintain itself. Several situations of this same type were worked but no Physa could be found. In the other stations, however, where Physa were absent the wave action was no greater than at stations where it was abundant. Depth of water is a factor in the distribution. Physa was never found in water over 2½ feet deep; this does not alone explain its absence in some of the stations since in all of them except the lake channel the water at shore line was not over 3 inches deep. The gradient may have an effect on the distribution inasmuch as, in case of station 9, it is so steep that it allows large waves to break at shore line causing a molar action too great for the snails. The same is true of station 5 which is a rubble beach. At other stations where Physa is absent the wave action is not great. Oxygen supply apparently also has an influence on the distribution of the snail. It is always found near the surface of the water and in most cases in a position where it is covered with water only part of the time, that is as the waves come in and submerge them. The snail was also found where the water was quiet but always at shore line partly exposed or on top of water-lily leaves. It is found in greatest abundance where water breaks in ripples.

The nature of the substratum in connection with wave action is apparently the limiting factor in the distribution of *Physa ancillaria*. In station 9 (Rubble Beach) the rubble is constantly shifting due to the wave action and it is impossible for the snails to get a foothold there. At station 10 (Sand Beach) the constant shifting of the sand prohibits their living there. In station 8 which is a sand beach with a row of rocks at shore line, Physa were found clinging to the rocks but none were found on the sand bordering the rocks. This shows that sand is an effective barrier. At station 11 no Physa could be found on the substratum, which is muck; however, there is plenty of vegetation at this station for them to live on and their absence from this station may be due to something else.

Limnea humilis

Limnea humilis was found in 8 of the 14 stations. At some stations it was very numerous, as in station 3 where 122 were found in one square foot. It is closely associated with *Physa ancillaria* in this region, but it is not quite so widely distributed.

Temperature is apparently not a limiting factor as the temperatures where it was not found fall within the range of temperature where it was found. The vegetation or the lack of it is not a factor either, because the snail was found both where there was vegetation and where there was none. Oxygen supply cannot be a limiting factor since it was found where there was plenty of oxygen and in stations like station 12 where the oxygen supply is much less than those with plenty of wave action. The snail was missing both places, with plenty of wave action and where there was quiet water, so oxygen supply is apparently not a limiting factor.

Exposure to wave action does have an effect on the distribution. In station 9 the wave action is very great and the snail is missing; other qualifications of this station are the same as at several stations where the snail is found. At other stations where it is lacking, however, the wave action is not as great as it is at station 4 where the Limnea were found in abundance. This snail is much like Physa in regard to depth of water. It is never found in more than three feet of water and this condition is no doubt a strong factor in their distribution; this fact coupled with the wave action apparently explains the absence of this snail at station 9. It does not, however, explain the lack of it at the other stations, as the water at shore line in each case is only an inch or two deep. The gradient, no doubt, has an effect inasmuch as it is an accessory factor in determining the magnitude of the waves. In stations 9 and 5 it is very steep and allows large waves to break at shore line. This causes a shifting of the substratum and Limnea is not able to maintain itself here. Limnea was never found on as steep a gradient as Goniobasis and Physa.

The nature of the substratum linked with the wave action is apparently the main factor in the distribution of this snail. In every station where the snail was missing the substratum was of such a nature that it was disturbed by the waves or by the seiche. They were found at Fisher's Pond where there is a muck bottom but the snail was on the vegetation and not on the muck. Sand, rubble, and muck are apparently barriers to Limnea.

Planorbis parvus

This snail was found in three of the fourteen stations, namely 4, 8, and 13. Station 4 is an approaching pond condition; 8 is an open harbor, and 13 is an old pond.

Temperature is apparently not a limiting factor in the distribution because they were found in temperatures from 22 degrees centigrade to 27 degrees centigrade, and these temperatures fall

within the range of the temperature of the stations where *parvus* was present. The nature of the substratum is not a factor, since this snail was found on rocks, plant stems, mud bottoms, and debris.

Depth of water is apparently one of the limiting factors for these snails. They were always found in very shallow water or on vegetation near the top of the water. It does not, however, explain the snail's absence from the other stations which provided shallow water and vegetation. Exposure to wave action is undoubtedly another factor in the distribution of *Planorbis parvus* since they were always found in well-protected places with little or no wave action. The gradient is a factor inasmuch as it limits the size of the waves acting on the habitat; at station 4 for instance the gradient here is so gradual that, although the station is somewhat exposed to the east, the waves are spent before they get to shore line. In each station where this snail occurred there was an abundance of vegetation and this condition may be one of the biggest factors in its distribution. Oxygen supply may be a limiting factor also. Since it is always found with vegetation, which we know tends to increase the amount of oxygen in water, the oxygen supply may be the important item, although the writer believes that the important limiting factors in the distribution of this snail are wave action and vegetation.

Planorbis exacutus

Planorbis exacutus was found at only one station, Station 13 (Fisher's Pond). It is taxonomically closely related to *Planorbis parvus.*

The gradient was very gradual here but since the snail occurred only on the vegetation, the gradient would not be an influence. The nature of the substratum likewise would not be a direct factor inasmuch as the snail was found only on the vegetation. It would be indirectly, however, inasmuch as substratum is a habitat factor. Exposure to wave action probably is a factor in the snails distribution but this does not explain its absence in the other stations where there was no wave action. The depth of water may have some influence; exacutus is very closely related to parvus and the latter is always found in shallow water.

Temperature is apparently the most important factor in the distribution of *Planorbis exacutus* since it was only found at one station and the temperature at that station was 17 degrees centigrade, which is lower than any other station by 4 degrees. Vegetation is undoubtedly another important factor in the distribution since it was found only on vegetation. The presence of an abund-

ance of vegetation would tend to lower the temperature on account of the shade afforded.

Pleurocera acuta

This snail was found in 3 stations; it is closely related to Goniobasis but is not so widely distributed.

Pleurocera was found in temperatures ranging from 24 degrees to 20 degrees centigrade, so temperature is not a limiting factor since these temperatures fall within the range of temperatures at the other stations. Depth of water has no influence since they were found in water 6 inches deep and 35 feet deep. Pleurocera occurs both in vegetation and where there is none, so evidently the presence or absence of vegetation is of no importance. Gradient might be a factor since it was always found on a very gradual slope, but this does not explain its absence in several other stations where the gradient is quite gentle. As to what effect the oxygen supply has in the distribution of this snail it is hard to say since the oxygen supply at station 14 is not known and furthermore, changes during the different seasons of the year.

Exposure to wave action linked with the nature of the substratum is probably the most important factor in the distribution of *Pleurocera acuta*. In station 10 it was found where there was but little wave action and at station 11 it was found ½ mile in East Harbor, while at station 14 it was in 35 feet deep where there would be but very little movement of the water. In every case it was found on a sand or rock substratum. However, it did not occur on a sand substratum if this was exposed to wave action.

Campeloma rufum

Campeloma rufum was found only in one station, namely Squaw Harbor (station 12).

Temperature is apparently not a factor in the distribution of this snail since it was found in water of 22 degrees centigrade and 4 other stations had the same temperature.

Exposure to wave action is apparently an important factor in the distribution of this snail; at station 12 (Squaw Harbor) and at Terwilliger's Pond (an open pond) where this snail was also found in abundance the water was always quiet. *Campeloma subsolidum* which is very closely related to *Campeloma rufum* was found in abundance at East Harbor where the water is never seriously disturbed. Gradient may be an influence inasmuch as it determines the wave action, amount of deposits, and growth of vegetation. Presence of vegetation is apparently a factor since this snail was in each case associated with rank growths of vegetation. Oxygen sup-

ply may also be a factor since they are always associated with vegetation. The nature of the substratum seems to be a very important factor inasmuch as it was always found buried in the muck. Depth of water may have some effect since it was always found in shallow water.

Campeloma subsolidum

This snail was found at only one station (East Harbor). It was rather abundant and was found in several of the zones. It is very closely related to *Campeloma rufum* and the factors in its distribution are the same as in the case of that snail.

Ferrissia fusca

Ferrissia fusca was found at stations 11 and 12.

The temperature of these stations falls within the range of temperature of the stations where it was not found so evidently is not a factor in the distribution. In every case this snail was found on vegetation so substratum would not be a direct influence, although it might be indirectly so as a factor in limiting the wave action, amount of deposit, and amount of vegetation. This snail was found two feet beneath the surface and at the surface of the water and depth is probably not a limiting factor.

The presence of vegetation seems to be an important factor in the distribution of *Ferrissia fusca* because in each case it was found clinging to vegetation. Oxygen supply may also be a factor since it was always found in vegetation. Lack of wave action is undoubtedly a factor since they were found only in quiet water; quiet water allows growth of plants which is no doubt the most direct factor.

Ferrissia parallela

This snail was found in the same stations with *Ferrissia fusca*, and under the same conditions so the factors in its distribution are the same as for fusca.

Planorbis trivolvis

Planorbis trivolvis was found in stations 11 (East Harbor), 12 (Squaw Harbor), and 13 (Fisher's Pond).

The temperature apparently has no effect on its distribution since it was found in temperatures of 17 degrees centigrade and 27 degrees centigrade. Depth of water is probably a factor because they were in water less than 3 feet deep. The gradient is very slight in each station where this snail was found and probably has an indirect effect inasmuch as the vegetation, sediment, and size of the waves depend to a certain extent on gradient.

The nature of the substratum in the case of this snail is a very important factor in its distribution since it was always found on a substratum of muck and in all cases of this kind of substratum it was found. Wave action is a factor because they were always found in quiet water. The presence of vegetation is no doubt a factor since they were always found where there was a heavy growth of vegetation. Oxygen may be a factor because it was always found in association with vegetation.

Amnicola limosa

This snail was found at only two stations (Squaw Harbor and East Harbor) but was present in considerable numbers at both of them.

The temperatures of these stations fall within the range of temperature of the other stations so it is evidently not a factor in distribution. They were in every case found on vegetation so substratum would only be a factor indirectly, if at all.

The presence of vegetation is no doubt a limiting factor since in every case the snail was found on vegetation. The depth of the water *may* be a factor since the snail was always found at or very near the surface of the water. Exposure to wave action is probably another factor since the snail was found each time in very quiet water. Oxygen supply may also be a factor since the snail was always found in vegetation. The most important factor apparently is presence of vegetation.

Valvatia tricarnata

This snail was found in one station, and that was the Lake Channel station. According to Baker the snail is typically a plant feeder and lives in shallow water. Specimens of this species have been sent to the writer from Sandusky Bay by Mr. Wibur Tidd of the State Fish and Game Commission and they were collected in shallow water. Because of the small number of this species collected the writer will not attempt to name the limiting factors in its distribution.

Limnea woodruffi

Only two specimens of *Limnea woodruffi* were found and these were in the Lake Channel at a depth of 35 feet.

The amount of oxygen in water that deep would change a great deal from season to season and for this reason this factor will be omitted. The substratum here was rocky with some sediment and is probably not a limiting factor since a great many of the stations furnished this type of substratum. In water this deep there would

seldom be a great amount of water action so this may be a factor in its distribution. The pH of this station is the same as in 8 others so it would not be a factor. The gradient is gradual at this station and inasmuch as a number of other stations had approximately the same gradient it is apparently not a factor. Lack of vegetation would have no effect since a number of stations provided this conition.

The temperature may be an important factor in the distribution, the temperature at this station being 17 degrees centigrade. According to Baker they are always found in rather deep water and the low temperature may be the important condition. The depth of water is apparently an *important* condition inasmuch as it is always found in deep water. Transparency at station 14 was considerably less than 100 per cent and this may be a factor. Since the pressure increases greatly with depth of water this may be an important factor in the distribution of this snail.

Succinea higginsia

This snail was found only at Squaw Harbor. It was found, however, in several other locations in conditions very much like those at station 12.

The temperature at station 12 was 22 degrees centigrade and as four other stations from which the snail was absent had the same temperature it apparently is not a limiting factor in the distribution of this species. The nature of the substratum is not important since they were found on rocks, mud, vegetation, and debris.

In each case where this snail was found it was at the surface of the water or crawling on the mud entirely out of the water, so oxygen supply is apparently a factor in its distribution; quiet water is no doubt important since the snails were always found where the water was very quiet. The gradient was gradual in the stations where this snail was found and may be an influence in their distribution. The presence of vegetation may be a factor since it was always found where there was a rank growth of vegetation, but it was not always found on the vegetation and it is probable that the presence of vegetation is merely incidental.

In the following table on Distribution Range of Snails, some terms and abbreviations were used which might be well to explain.

In the case of the gradient such abbreviations as 4 ft. in 90 were used; this is meant to denote 4 feet in 90 feet. In the case of temperature, since all these snails are subjected in winter to freezing or near freezing temperature, only the highest degree (centigrade) is recorded. In some cases in referring to the depth the

words "at surface" were used. This means that the snails were either very close to the top of the water or clear beyond the water.

In the matter of oxygen supply the writer is not sure in each case, but from the nature of the wave action, abundance of vegetation and currents estimations were made.

TABLE SHOWING DISTRIBUTION RANGE OF THE SNAILS

Snails	Temp. in C.	O. Supply	Nature of Sub-s.	Wave act.	Depth	Gradient	Vegetation
Goniobasis l.	27	Great-Small	Rock Sand Mud	Great None	1 in.-35 ft.	3 ft.-90	Present Absent
Physa an.	27	Great-Small	Rock Stone Vegetation	Great None	2 ft. Surface	4 ft.-100 5 ft.-20	Present Absent
Limnea humilis	27	Great-Small	Rock Stone Vegetation	Great None	Surface 1 ft.	4 ft.-100 5 t.-20	Present Absent
Planorbis par.	27	Moderate	Stone Vegetation	None	½ in.	14 in. 35 ft. Flat	Present
Planorbis ex.	17	Moderate	Muck	None	Surface	Flat	Present
Pleurocera ac.	27	Moderate	Sand	None	3 in.-35 ft.	Flat 3½ ft. 100	Present Absent
Campeloma ruf.	22	Moderate	Muck	None	8 in.	Flat	Present
Campeloma sub.	27	Moderate	Muck	None	1-2 ft.	Flat	Present
Ferrissia fus.	27	Moderate	Muck	None	8-12 in.	Flat	Present
Ferrissia par.	27	Moderate	Muck	None	8-12 in.	Flat	Present
Planorbis tri.	27	Moderate	Muck	None	2-18 in.	Flat	Present
Amnicola lim.	27	Moderate	Muck	None	Surface	Flat	Present
Valvatia tri.							
Limnea woodr.	20	Moderate	Rock	Little	35 ft.	Flat	Absent
Succinea hig.	22	Great	Rock Mud	None	Surface	Flat	Present

OPTIMUM CONDITIONS FOR EACH SPECIES

The oxygen supply and the temperature will be omitted in naming the optimum conditions for the different species. No attempt was made to find the exact oxygen content of the water during the collecting, and for this reason it will be omitted. (This factor would make a very good problem and would undoubtedly add a great deal to the knowledge of the distribution of the snails). The temperature of the water during the winter goes to or nearly to freezing, and as they were found in temperatures in the summer as high as 27 degrees centigrade, it shows that their range of temperature is great and that it probably plays a very little part if any in their distribution.

The nature of the substratum will be indicated by words like

muck, stony, etc.; wave action will be denoted by terms, strong, moderate, great or none; depth will be given in inches, feet, or at surface; gradient will be indicated by figures such as 3 in. in 14 ft., or by the term flat; presence or absence of vegetation will be denoted by terms present or absent.

TABLE SHOWING OPTIMUM CONDITIONS FOR EACH SPECIES

Snails	Nature of sub-s.	Wave act.	Depth	Gradient	Vegetation
Campeloma subsolidum	Muck	None	10 in.	Flat	Present
Campeloma rufum	Muck	None	8 in.	Flat	Present
Pleurocera acuta	Sand Rock	None	18 in.	Flat	Absent
Succinea higginsi	Rock Mud	None	Surface	Flat	Present
Planorbis trivolvis	Muck	None	4 in.	Flat	Present
Goniobasis livescens	Rock	Riffles	4 in.	3 ft. in 20 ft.	Present
Physa ancillaria	Rock	Riffles	Surface	14 in. in 35 ft.	Absent
Limnea humilis	Rocky	Riffles	Surface	14 in. in 35 ft.	Absent
Planorbis parvus	Muck	None	Surface	Flat	Present
Limnea woodruffi	Rock	None	35 ft.	Flat	Absent
Planorbis exacutus	Muck	None	Surface	Flat	Present
Valvatia tricarnata					
Amnicola limosa	Muck	None	Surface	Flat	Present
Ferrissia fusca	Muck	None	10 in.	Flat	Present
Ferrissia parallela	Muck	None	10 in.	Flat	Present

SUMMARY

In order to settle to complete satisfaction the effect of certain possible factors considerable experiment would be necessary; however, in the light of the data collected a summary will be made of the most important conclusions reached relating to the distribution of the snails.

1. The temperature, transparency, and pH of the water apparently had little or no effect in the distribution of the snails.

2. Wave action along with the nature of the substratum were the two most important factors in the distribution of *Goniobasis livescens, Physa ancillaria* and *Limnea humilis.*

3. The lack of wave action in conjunction with the nature of the substratum are the important factors in the distribution of *Planorbis trivolvis, Pleurocera acuta, Limnea woodruffi,* and *Succinea higginsi.*

4. The lack of wave action along with the nature of the substratum and presence of vegetation are the important factors in the

case of *Campeloma rufum, Campeloma subsolidum, Planorbis parvus,* and *Planorbis exacutus.*

5. The condition of wave action linked with that of presence of vegetation are the two important requirements of *Ferrissia fusca, Amnicola limosa,* and *Pleurocera acuta.*

6. The pulmonates were always found where there was considerable wave action, or near the surface, and sometimes on land; while the branchiates were found in deeper and more stagnant water.

7. The greatest snail population was found in the first six inches of water.

8. An exposed cliff (Gibraltar Cliff) with steep gradient was apparently least adapted for habitat of snails (only 1 species found), while an open pond (Squaw Harbor) with little wave action and gentle gradient was the best suited for snails (10 species found).

9. The wave action is the greatest factor in the distribution of the snails.

10. In general the writer's conclusions agree with those of Krecker, Baker, and Robertson.

Literature Cited

1902—Baker, Frank Collins.

The Molluscs of the Chicago Area. Bulletin No. III, Part II of the Natural History Survey.

1916—.....

The Relation of Molluscs to Fish in Oneida Lake. Technical Publication No. 4. The New York State College of Forestry.

1924—Krecker, Frederick H.

Conditions under which Goniobasis livescens Occurs in the Island Region of Lake Erie. *Ohio Journal of Science,* Vol. 24.

1915—Robertson, A. D.

The Molluscs of Georgia Bay. In Studies from the Biological Station of Canada, 1911-1914. Fasciculus II, Fresh Water Fish and Lake Biology. Suppl. to 47th Ann. Rept. Dept. of Marine and Fisheries, Ontario, pp. 95-111.

UNIVERSITY OF RHODE ISLAND
3 1222 00682 0198